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CR - 130572

January 31, 1973

ERTS Contracting Officer
Code 245, GSFC
Greenbelt, Maryland 20771

Subject: Type II Progress Report No. 1

Period Covered: 1 July - 31 December 1972

Title: A Scheme for the Uniform Mapping and Monitoring of
        Earth Resources and Environmental Complexes Using
        ERTS-1 Imagery

GSFC ID: PR 534
          SR 275

Contract No: NAS5-21830

OBJECTIVES

To develop, test and specify a practical procedure and system for the uniform mapping and monitoring of natural ecosystems and environmental complexes from space-acquired imagery.

With primary emphasis on ERTS-A imagery, but supported by appropriate aircraft photography as necessary, our objective furthermore is to accomplish the following:

1. Develop and test in a few selected areas of the western United States a standard format for an ecological and land use legend for making natural resource inventories on a simulated global basis.

2. Based on these same limited geographic areas, identify the potentialities and limitations of the legend concept for the recognition and annotation of ecological analogs and environmental complexes.

An additional objective is to determine the optimum combination of space photography, aerial photography, ground data, human data analysis and

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automatic data analysis for estimating crop yield in the rice growing areas
of California and Louisiana.

MAJOR ACCOMPLISHMENTS

Rice Analog Studies:

Our Data Analysis Plan does not call for concerted work on this phase
of the project until March 1973. To support this work, however, the detailed
Data Analysis Plan, and schedules for field studies and aircraft overflights
have been completed for initiation of activity in February 1973. The next
phase of activity will begin with a ground truth and cooperator contact
mission now scheduled for March 12, 1973.

Just prior to receipt of ERTS data and as scheduled in the preliminary
Data Analysis Plan, Poulton and Welch flew a reconnaissance mission of the
two test sites to be used for this phase of the project. At that time local
cooperator contacts were made according to plan and preliminary arrangements
were made for local cooperation. Specific test sites were selected and the
NASA aircraft support plan for rice study in California was revised and
filed with NASA/Ames U-2 operations. We are awaiting notification from the
RB-57 operations at NASA/MSC indicating whether they will be able to provide
aircraft photo support for us in the Louisiana rice study areas.

- The California rice test area has been imaged by ERTS-1 on several
occasions allowing us to analyze the usefulness of ERTS imagery for delineating
rice fields and to detect areas where crop yield reductions are apparent.
Rice crops, having a relatively high vegetative vigor, appear as bright red
areas on ERTS color composites taken during the summer growing season.

When deficiencies occur in rice stands that are visible on ERTS imagery, they appear as a non-red area within fields, and a significant yield reduction will occur. We have detected a considerable number of such areas in California rice fields while interpreting ERTS color composite images taken on July 25 and 26, 1972.

Both aerial photographs taken by the co-investigator, and consultation with cooperating agricultural extension specialists confirm that those areas identified as having problems did, in fact, produce less grain than surrounding healthy crops. No effort was made using ERTS images to predict yield or to estimate the magnitude of yield reductions in those fields observed because data are incomplete for the 1972 growing season and arrangements have been made to perform such evaluations during the 1973 rice season. However, we are confident that (1) we will be able to classify correctly all rice fields in the California test area using ERTS imagery taken during the summer growing season, and (2) we will be able to make judgments relating to general health and vigor of rice crops on a large field basis using ERTS imagery. The minimum size of the field interpretable has not been determined for ERTS photos but for aircraft photos used in support of ERTS imagery it has been shown by earlier investigations that acre-by-acre samples of crop condition data can be obtained from photo interpretation of aerial photography.

Vegetational Analog Studies:

The work we have done to date indicates that the chances of success in defining and characterizing meaningful ecological analogs and in determining the signature characteristics for these analogs as well as the repeatability of analog signatures is very good. Our expectation is, therefore, one of complete success in attainment of objectives of the study.

Immediately following our aerial reconnaissance of all test sites in August 1972, we received ERTS-1 data for the Sierra-Lahontan site. With imagery in hand the PI conducted a ground truth trip through this area across all examples of major vegetational types, recorded ground truth notes identifying specific vegetational types and took supporting ground photographs illustrative of the various analogs encountered to better define the ecological complexes that comprise the landscapes transected. These notes and photographs will be used to identify specific analogs on the working copies of the ERTS-1 color prints.

As indicated in the initial proposal, however, all analogs are not equally well represented in all test areas. In some cases important vegetational analogs are well represented in one test site only. In these instances we will be able to determine the signatures of these examples, the fidelity of their signatures at different locations within the test area and the degree and accuracy to which these candidate analogs can be discriminated from other analogs within and among test areas. We will not be able, however, to determine the consistency of their signatures between the interregional test areas. This latter objective could be achieved by retrospectively ordering (in the closing phases of our study) carefully selected frames covering new locations where these single-example analogs are known to occur. We will be alert to the magnitude of this problem as the work moves ahead.

Table 1 lists the natural vegetational analogs we have identified in the two test areas to date and indicates the adequacy of representation of each in the respective areas.

NATURAL VEGETATION ANALOG		Situation regarding listed analogues within each selected test site marked with X in appropriate column			
		Present in test site and a good example to meet project objectives		Present in test site but marginal value for thorough analysis	
Name	Map Symbol	Sierra-Lahontan	Colorado Plateau	Sierra-Lahontan	Colorado Plateau
Herbaceous Types	310		X	X	
Distichlis Stricta types (Meadows Gram/Agp)	316	X	X		
Ann. form of grasses (Bromus tectorum)	312		X	X	
Forb types	313	X	X		
Bunchgrass	314	X	X		
Shrub-Scrub types	320	X	X		
Atriplex confert	324.1		X	X	
Sarcobatus recompiculatus	324.51		X	X	
Sarcobatus baleyii	324.52		X	X	
Blackbrush types	324.6	X			X
Shrub Steppe	325		X	X	
Artem. arbuscula/nova	325.1	X	X		
Artem. tridentata	325.2	X	X		
Artr/Chna	325.3		X	X	
Putr	325.4		X	X	
Artr/Ruta	325.5		X	X	
Decid.macrophyllous shrub	326	X	X		
Mountain Brush (Amelanchis, Symph, Related)	326.3 326.3	X	X		
Willow	326.5		X	X	
Willow/Carex	326.51		X	X	
Deciduous Oak scrub	326.1	X			X
Evergreen shrubs	327	X	X		

TABLE 1. Natural vegetation analogs available for study in the test sites.

| NATURAL VEGETATION ANALOG | | Situation regarding listed analogues within each selected test site marked with X in appropriate column | | | |
| Name | Map Symbol | Present in test site and a good example to meet project objectives | | Present in test site but marginal value for thorough analysis | |
		Sierra-Lahontan	Colorado Plateau	Sierra-Lahontan	Colorado Plateau
Manzanita	327.2	X			X
Mountain mahogany	327.4		X	X	
Snowbrush	328.3	X	X		
Chamise types	328.5	X	X		
Savanna-like types	330	X	X		
Juniper/shrub			X	X	
Mountain mahogany/shrub			X	X	
Forest & woodland types	340	X	X		
Open needleleaved forest & woodland types					
Juniper			X	X	
Ponderose pine		X	X		
Dense needleleaved forest & woodland types		X	X		
Pinyon-Juniper			X	X	
Ponderosa pine-Doug.fir		X	X		
Mixed fir forests		X	X		
True fir forests		X	X		
Spruce fir forest			X	X	
Open deciduous forest/woodland types					
Oak woodlands		X	X		
Open evergreen/hardwood forest woodland types					
Evergreen oak woodlands		X			X
Dense deciduous hardwood forest/woodland types					
Bottomland hardwoods				X	X
Aspen types			X	X	
Dense evergreen hardwood/woodland types					
Evergreen oak types				X	X

TABLE 1: Natural vegetation analogs available for study in the test sites.

NATURAL VEGETATION ANALOG		Situation regarding listed analogues within each selected test site marked with X in appropriate column			
		Present in test site and a good example to meet project objectives		Present in test site but marginal value for thorough analysis	
Name	Map Symbol	Sierra-Lahontan	Colorado Plateau	Sierra-Lahontan	Colorado Plateau
Agricultural crops areas	400		X	X	
Cover crops Row crops Orchards & vineyards Non-producing & fallow					
Barren lands	100	X			X
Playas	110	X			X
Aeolian barrens	120		X	X	
Rocklands	130	X	X		
Badlands-silt, clay, shale beds	150			X	X

Our project is conceived as an application of the human interpretation approach with the use of various photographic products, aided as desirable or necessary by the use of such supplementary support devices as color combiner manipulations and density slicing, as appropriate to maximum information extraction by the human interpretation approach. For budgetary and other reasons the project was not designed to emphasize digital data analysis as a support or analytical technique--even though we recognize the value of this approach.

In keeping with the above we have found that from interpretation of the ERTS images stereo examination in the side-lap area is highly beneficial as an interpretation support technique, especially in hilly and mountainous terrain. The advantages of binocular reinforcement are also significant in interpreting the undulating and flat relief areas. Because many vegetational interpretation decisions are made on the basis of associated and convergent evidence, an accurate impression of relief features, as visualized from ERTS side-lap stereo significantly increases the interpretability of the images in terms of vegetational parameters. This is particularly important in the interpretation of the black-and-white prints because one does not have the benefit of the expression of IR reflectivity in separating vegetational signature components from soil or topographical features that have identical or similar grey-tone signatures.

In making vegetational interpretations from ERTS it is important to recognize that one does not have the image texture component to work with to the same degree that we are accustomed when interpreting from conventional, large-scale, high resolution aerial photography. From the ERTS we can work with pattern and tone or color and the gross spatial relationships among the

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features imaged and the impressions of relative relief and drainage patterns. In the monocular view, these latter characteristics can be inferred only from patterns of dissection that are associated with drainage systems and the "shadow" effect of relief. We have found these latter can be misinterpreted in terms of the amount of relief when viewed monocularly but the factor of doubt is high. In stereo there is seldom doubt about relief and landform as associated evidence. This leads to better vegetational identification decisions.

It is of importance to note the difference in using ERTS photos in the field versus aerial photos for field checking specific locations. When a ground observer views an area with aerial photo in hand where he has a horizontal view that is unrestricted by terrain or dense vegetation, he observes nearby features having vertical expression such as trees, shrubs, houses, barns, hills, etc. and relates his actual photo position by finding and noting on the photo each such visible feature. Even where terrain and patchy dense vegetation may restrict his view he can still find his position on the aerial photos if he is reasonably attentive to the changing scene as he traverses an area.

Such is not the case for space photos. The features he sees from the ground such as trees, houses, etc. and uses in aerial photo interpretation are not visible on space photos and it is quite difficult to find ones exact location, and perhaps even general location, in the field by inter- preting space photos alone. This problem is due largely to the inability to see recognizable features in their plan view on the small scale ERTS photos.

Two factors are important to remember in this matter. First, agricultural areas with their characteristic cultivated field patterns may

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provide important "check points" in locating ones precise position on space photos, an advantage not possible in wildland areas. Second, with an increase in height of the observer's station (perhaps in an airplane or on a hilltop) the ability to see the patterns and juxtaposition of recognizable ground features provides vital clues to determining the true position of a ground observation point. It is not possible, however, to use small vertical features such as individual trees, houses, mounds, etc. to identify ones position. Such features are below the resolution capability of the ERTS space photos.

To compensate for this problem it is wise to plan a ground traverse carefully beforehand, whether by vehicle or on foot, using the space photo as a map for general orientation and field trip planning. In addition it is necessary to use a conventional map and/or aerial photography to determine the probable accessibility and trafficability of a particular site and route because barriers to vehicle and foot travel may not be visible on the space photos. In some areas following a compass route may be a very useful navigation aid for vehicle or foot travel to traverse from one check point to the next.

The legend system has been adapted to the vegetational communities found in the various test sites and has been successfully applied in preliminary delineation and identification of the landscapes in the Sierra-Lahontan test area. It has been used for annotation of the vegetational analogs observed on the aerial reconnaissance trip over all test sites. The legend system is working very well for the more arid vegetational conditions and for the barren land and water resource classes. We are experiencing some difficulties with the vegetational classes of #330, Savanna-like types and 340, Forest

and Woodland types. It appears that the legend progressed too abruptly from physiognomic/structural characteristics to floristic criteria in the case of these prominently arborescent vegetational classes. The two classes 330 and 340 are currently being revised.

Examination of multidate ERTS color images has permitted us to visualize a useful vegetational growth progression in the Lake Tahoe test site by comparing an ERTS color image taken on 26 July with one taken on 17 September (providing stereo viewing of the test area). Because onset of vegetative growth commences at predictable times based on species types and the characteristic local environmental conditions (temperature, humidity, precipitation, wind, day length, etc.) it can be observed and stratified (its boundary delineated) by aerial or space photos taken at periodic intervals.

We interpreted a stereo pair of ERTS color photos using the 26 July image as the left-hand member of the pair and the 17 September as the right-hand member. Vegetation on the September image was uniformly mature appearing as a deep red color with some variation due to plant species, and site differences. The July image, on the other hand, had several vegetation communities located at the higher elevations that displayed a bright red color typical of a newly emerging flush of springtime growth. The vegetation in the lower elevations had progressed through the springtime growth and appeared a deeper red--essentially the same as the September image.

Thus, there was a significant difference in the appearance of certain vegetation complexes located at higher elevations between the July and September imagery. These differences correspond to particular vegetation complexes responding to environmental conditions. It is possible to visualize these complexes by viewing the July and September photos as a

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stereo pair. By "blinking" the eye which focuses on the July image, the areas of vigorous new vegetative growth will appear to turn on and off as red lights.

We plan to exploit this phenomenon for mapping unique vegetation boundaries by using ERTS photos taken at each 18-day cycle (weather permitting). One member of a pair will be an image taken in mid to late summer after all vegetation had reached maturity but before seasonal dieback, and the other member of the pair will be one taken at progressively later dates starting in early springtime as vegetation complexes at lower elevations begin to exhibit vigorous growth.

While the blink technique permits the interpreter to visualize this phenomenon with a minimum of effort, we plan to devise image combination and enhancement techniques using optical display devices whereby a composite image can be made showing the desired vegetation complexes as a unique color.

By progressing through the springtime growing season using appropriate paired photos it should be possible to make useful delineations of certain discreet vegetational communities by such a multidate comparison technique. We feel that even where site elevation is not a factor this technique may be useful because most vegetation types begin growth at a particular date in the springtime and during that time exhibit a unique contrast with surrounding members of the community. Perhaps differing plant communities have a greater photographic contrast at that time than at any other time during the growing season.

We plan to make comparisons of multidate imagery in agricultural crop evaluation as well as in wildland types. The vantage point, and thus the imagery provided by ERTS-type systems, is nearly ideal for such multidate

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comparisons. Except for shadow changes caused by seasonal sun angle progression, scene reflectance differences between dates of a particular feature represent important ecological information such as species differences, soil type boundaries, soil moisture changes, disease, insect or fire damage and environmental influences. We plan to exploit this valuable asset to the fullest extent possible for vegetation mapping and evaluation.

Test Site Reconnaissance:

A test site reconnaissance and ground truth mission was flown in the period August 10 to 31, 1972. All test sites for both phases of the project (Natural Vegetation and Rice Analogs) were visited, purposefully overflown and selected areas were photographed in 70mm and 35mm color and color infrared (CIR) aerial obliques. These photos will be particularly useful as a third stage sample toward defining ground truth. They are of sufficiently large scale to permit identification of most analogs at the classification level we anticipate usable with the ERTS. Some natural ecosystems will have to be identified by ground observation or reference to resource maps, especially in the more arid portions of the test areas. This work is scheduled for spring of 1973. To facilitate use of these photos in identification of ERTS-1 images, all flight paths have been plotted on 1:500,000 aeronautical charts together with the location and direction of key photos along the flight path.

On all reconnaissance work both by air and ground travel, a careful recording of observations was made and keyed to the flight path delineated on an aeronautical chart or highway map. Reviewing these recorded notes is time consuming but prior experience with space and high flight imagery experiments has shown voice recording of field observations to be far

superior to hand written notes. The key to full success lies in how well

dictated notes are tied to position on flight track and look direction at

the photo point during the recording of data. With clean 1:500,000 aero-

nautical charts in hand this is easy to accomplish. <u>It should never be</u>

<u>done after the fact.</u>

The following page is illustrative of our Quick-Look evaluation made of

all ERTS-1 frames as they came in from GSFC. Careful completion of this

form has the following advantages:

1. It organizes the approach to initial evaluation and gives a
   good idea about the information content of each frame, quality
   of imagery and interpretability of the classes evident.

2. If entries are made by a team of examiners it gives each the
   same experience and an initial judgment of where problems in
   interpretability may lie--recognizing that degree of familiarity
   with the subjects of the area is a strong determinant of differences
   among interpreters.

3. As these differences appear, having compiled this form together
   provides a good basis for group discussion of problem areas and
   for resolution of differences in interpretation. It can be, in
   fact, a team training aid of some significance.

4. As these records accumulate, comparison of them soon reveals the
   frames that will be most useful for the objectives of a project.

5. On occasion, others will want to know about the coverage in a
   specified area. This record is an excellent way to communicate
   information, especially after the initial team has pooled their

QUICK LOOK
PHOTO QUALITY AND INTERPRETABILITY SUMMARY

Type of Imagery: (X) ERTS *1*; (__)U-2/RB-57; (__) Aircraft.　Photo Date: *16 Sept 72*

Area or Location: *Sierra-Lahontan*　.　Band/Film-Filter: *MSS-5*

Frame No(s).: *1055-18053*　; Frame Name: *Walker Lake*

Type Imagery: *MSS-5 B&W Print, Matt finish*　Scale: *1:1,000,000*

Site Condition: (__) Wet; (X) Dry.　Image Useful in Project? (__) Yes; (X) No. (__) ??

FEATURES IMAGED	Percent Frame	Interpret- ability
100 - Barren land	2	A
110 - Playas	2	A
120 - Aeolian Barrens		
130 - Rocklands		
200 - Water Resources	2	A
210 - Ponds, Lakes, Reservoirs	2	A
220 - Water Courses, Permanent	1	B
280 - Snow/Ice	1	A
300 - Natural Vegetation		
301 - Density & Vigor High	2-	B
302 - " " " Moderate	4	B/C
303 - " " " Low		
304 - Vegetation Dormant	5	B
310 - Herbaceous Types		
320 - Shrub-Scrub Types	4	A
324 - Microphyllous Salt-Tolerant	3	B/C
325 - Shrub Steppe (Sagebrush)	3-	B/C
326 - Evergreen Macrophyllous		
327 - Deciduous Macrophyllous		
330 - Savanna Types		
340 - Forest and Woodland Types		
341 - Needleleaf	4	C
342 - Broadleaf Deciduous	1	D
343 - Broadleaf Evergreen		
344 - Needleleaf-Broadleaf		
400 - Agricultural Crop Land	2	A
410 - Cover Crops, Field & Seed	2	A/B
411 - Cereal and Grain Crops		
411.6 - Rice		
500 - Urban/Industrial Lands	1	C/D
540 - Transportation Facilities	1	B
580 - Resource Extraction (Mining)	1	C/D
600 - Obscured Earth Resources		
610 - Clouds (Type:_____)		
620 - Dust		
630 - Smoke		
640 - Smog		

Use Percent Classes

1 =	+ -	1%
2 =	1+ -	5%
3 =	5+ -	25%
4 =	25+ -	50%
5 =	50+ -	75%
6 =	75+ -	95%
7 =	95+ -	100%

Interpretability Classes

A = Positive, little chance for error.

B = Reasonable Certainty, Errors inconsequential.

C = Modest Chance for Error Highly dependent on associated/convergent evidence or local familiarity with area.

D = Large Chance for Error, little better than a guess.

Interpreter: *C.E.Poulton*

Date: *9 Dec. 72*
(day,month,year)

NOTE: Rate legend items only once for each scene unless image changes occur or quality improves. Generally score only RBV-2 or MSS-5.

Change Evident Since Last Examination, (X)Yes; (__)No; (__)Not Applicable.　If YES, Explain

Snow on Mt. Patterson 11,713'

REMARKS: *All of Fallon-Eastgate strip on No. edge of frame. Useable if printed on matt dried glossy instead of matt paper. SHOULD ORDER COLOR PRINT.*

Continued on Back (__).

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judgment and developed a revised group interpretation
of the scene.

This form intentionally includes only the broadest legend units that
we felt, ahead of time, should be discernible on ERTS-1, especially in the
color reconstituted form. To the extent that these initial interpretations
are accurate, it enables one quickly to group frames according to the number
of vegetation analogs represented thereon and to select for study those
frames that include the highest number of potential analogs.

Since we have had only limited examples of the color reconstituted
material to examine, we have made only a very limited number of these
evaluations of the CIR product. For vegetational interpretation, the color
product is highly superior. The most meaningful and accurate summaries
of the analogs represented and the interpretability of same can be made
only from this project.

Since this was a Quick-Look evaluation and color could not be placed in
the standing order, all of our evaluations were done on the red band,
black-and-white 9" x 9" product. This does give good definition among image
classes but identification is very difficult unless the specific area is
well known from ground experience or through detailed ground truth maps.
It was not the intent, however, that this Quick-Look evaluation would include
time for comparison with ground truth record. This is unproductive where
only black-and-white prints can be used. With the color product it would
be a productive second step as one moves into specification of image
characteristics representing each analog.

Where only the black-and-white product can be examined, we do not think
time spent in evaluating all repeat coverage with this form is justified.

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Once a good cloud-free image is obtained and evaluated, repeat evaluation in black-and-white single band coverage should be restricted to looking at cloud cover in terms of where the clouds are in relation to test areas, checking the usefulness block, and making a rather careful comparison for major and obvious changes in the imagery as recorded on the red band black-and-white product. The most worthwhile approach to vegetation and image change detection is on the color product. This kind of visual photo interpretation work should be limited essentially to color materials for all except a cursory examination. In addition, there is probably no reason to repeat the evaluation with every overpass, but repetition and careful comparison when phenological changes are known to have occurred would be very fruitful.

Identification of Intensive Study Areas:

To date we have chosen three areas to study in detail. These are areas where high altitude U-2 coverage is available and where analogs from each respective area can be located in respect to each other even though they are separated geographically by long distances. The areas shall be called Colorado Plateau, Sierra-Lohantan and Four Corners. The locations of each of the areas is outlined on the attached maps. These will be further refined and specified when the color reconstituted ERTS images are received. Location of U-2 flight coverage received to data including that which will be used in interpretation is also indicated on the maps.

The criteria for selection of these particular sites are:

a. Each selected area contains within its boundaries a very wide range of vegetational analogs for mapping and evaluation.

b. Areas were covered by Welch and Poulton on earlier low altitude fixed-wing aircraft observations supplemented by oblique aerial photographs to incorporate into ground truth data.

c. The accessibility of the area is such that subsequent travel and field work in the area can be accomplished efficiently at a minimum of costs.

SIERRA-LAHONTAN TEST AREA

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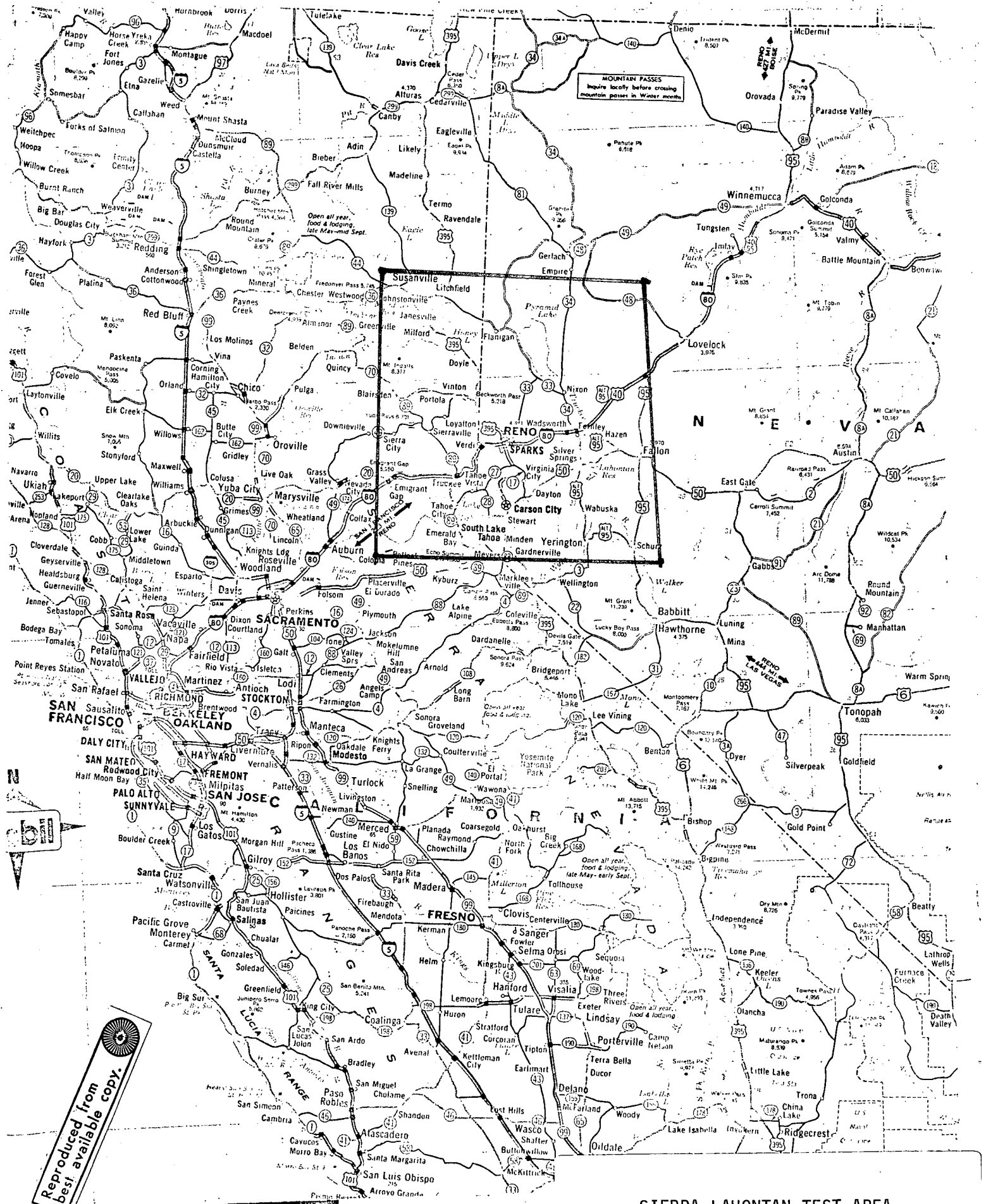
FOUR CORNERS TEST AREA

of the park.

Pinto Pony Riding Stable; Box 722, Sedona, Arizona 86336.
One-hour to 4-day horseback trips into Red Rock and Oak
Creek Canyon Country.

DECEMBER New Mexico pueblos—December 24,25, cere-
monial dances.
NOVEMBER Zuni, New Mexico—late November or early
December, Shalako Dance.
dances, arts and crafts displays, rodeo.

COLORADO PLATEAU TEST AREA
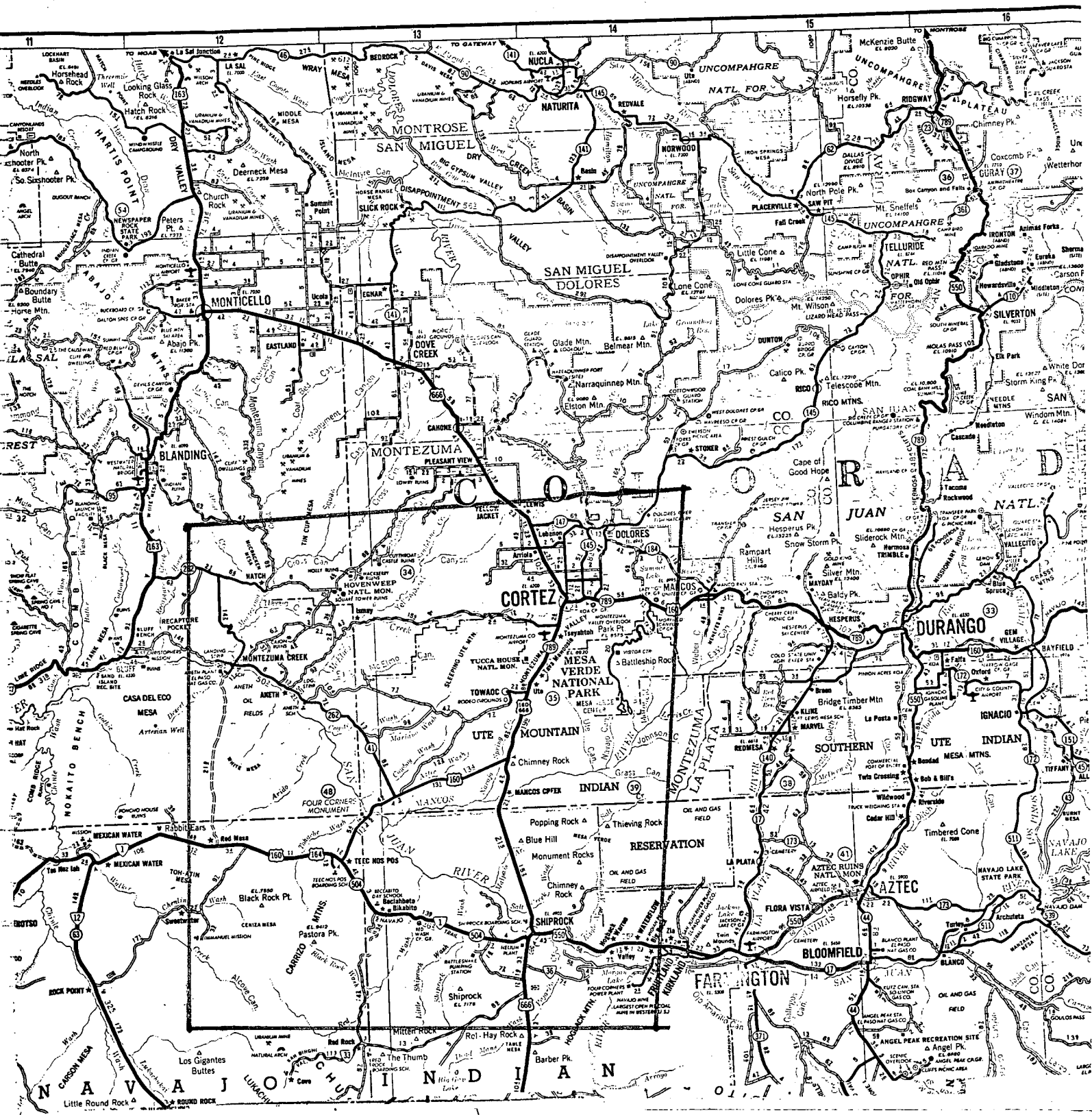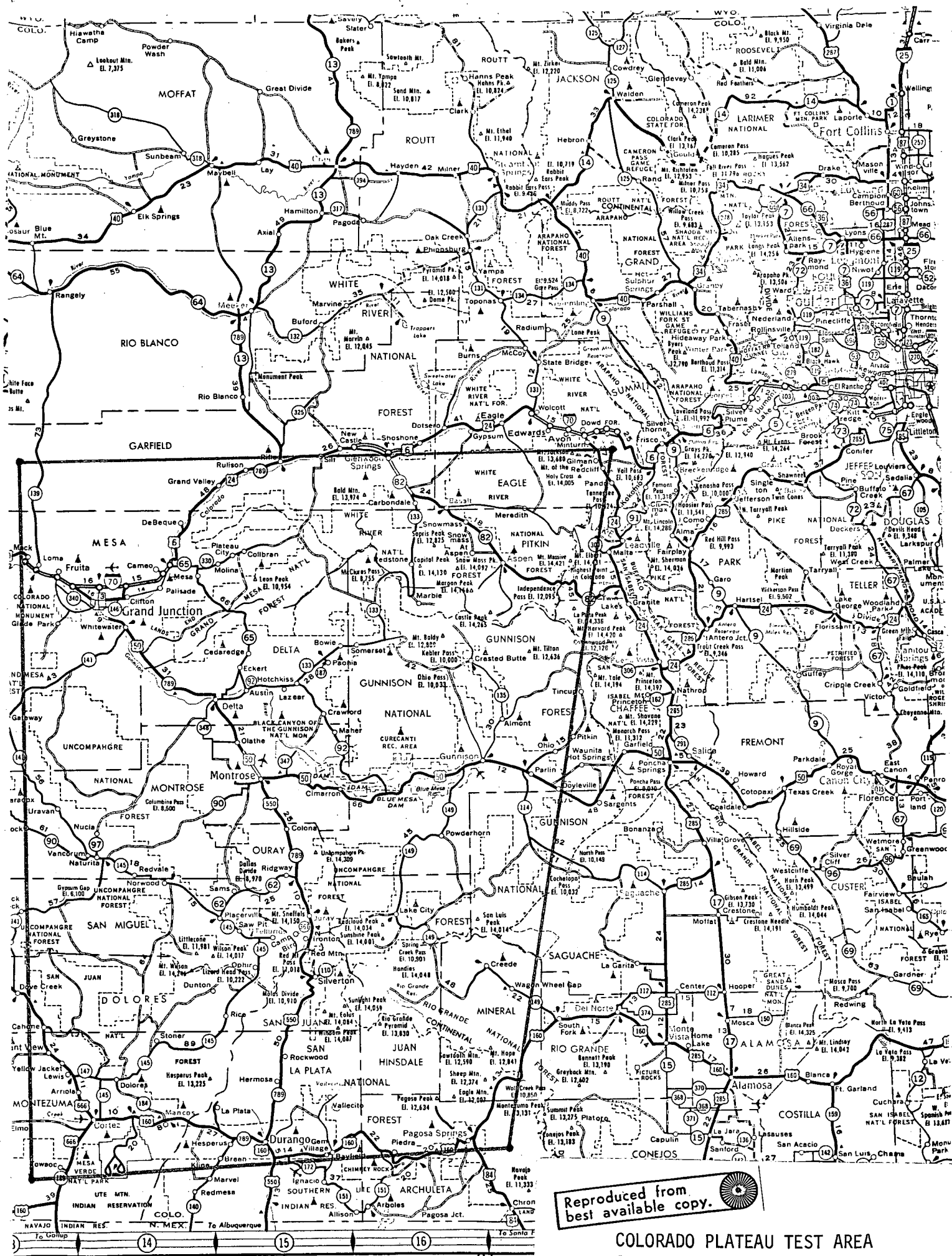
Evaluation of Available Images:

To this date, we have received no color composite transparencies or prints which we have ordered from the Sioux Falls facility or from GSFS(NDPF). We have been able to make a significant although minimal effort on our own as a result of Dr. Poulton's visit to Sioux Falls in October of 1972. At that time, he prepared images of small portions of our study area in the Sierra-Lahontan (Lake Tahoe) region. These were photographed from the screen of an optical combiner with a 35mm camera and reproduced for our study.

In addition to the above effort, we borrowed from another project file, an existing color composite (GE product) print and transparency (NASA NDPF) from an investigation being conducted near the Tahoe area. Copy negatives were used to make 14 x 14 inch enlargements on which we will work until such time as our standing color reproduction orders are received from NASA. These substitute color composites will not, however, allow inter-regional comparisons.

The images we have been able to examine through this reporting period have been third or fourth generation reproductions from borrowed material. As a result, the image quality is less than desirable, having lost some resolution through the copy process. However, we have been able successfully to test the legend by application to these images and to identify problem areas in legend refinement.

Legend:

Our working legend has been adapted for use in this study from earlier work by the PI (Poulton, 1972). The new revised legend follows the same concepts and we are finding that it works well for ERTS-application to the second digit level in the symbolic legend. We are also confident that identifications can be made at one and in a few instances possibly at two

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additional digit levels below this. In general, however, the portion of the legend that uses physiognomic/structural characteristics (i.e., from the 100'ds digit to the decimal point, e.g., 324) is the part of the legend that is going to be most consistently useful in direct ERTS interpretation by the human PI. The digits to the right of the decimal in the symbolic legend draw on floristic criteria (species or botanical taxa criteria) and these levels are more appropriate for use with higher resolution air-craft data and possibly for use in identification of training sets where digital data analysis and classification is to be done with the ERTS-1 imagery data.

We are confident that the 1st and 2nd legend levels, even for eventual global application, will not change, the third digit will in most every case require some degree of regionalization and thus probably will change as one moves into widely contrasting ecological regions or provinces. We are, however, trying to structure the symbolic legend so that all three digits left of the decimal point will be at least continent-wide in their appli-cability and hopefully global.

In achieving these goals, the only two areas still giving us trouble are the Savanna-like types, 330, and the Forest and Woodland Types, 340. We are currently considering some alternative physiognomic criteria for the units digit level in the case of these two major classes of natural vegetation.

The legend as it exists now to the tertiary level is shown in Table 2.

Table 2

LEGEND CLASSES FOR ECOLOGICAL & CROP ANALOG STUDY

Primary Classes

       100 - BARREN LANDS (5% vegetation cover, other than crop fallow)
       200 - WATER RESOURCES (free water surfaces)
       300 - NATURAL VEGETATION
       400 - AGRICULTURAL CROP AND IDLE LAND
       500 - URBAN AND INDUSTRIAL LAND
       600 - OBSCURED LAND (not visible, atmospheric obstruction)

Subclasses

  100 - BARREN LAND Subclasses

      110 - Playas, dry or intermittent lake basins
      120 - Aeolian barrens (dunes, sandplains, etc.)
      130 - Rocklands

         131 - Bedrock outcrops (intrusive & erosion-bared strata)
         132 - Extrusive igneous (lava flows, pumice, cinder and ash)
         133 - Gravels, stones, cobbles & boulders (usually transported)
         134 - Scarps, talus and/or colluvium (system of outcropping strata)
         135 - Patterned rockland (nets or stripes)

      140 - Shore-lines, beaches, tide flats and river banks
      150 - Badlands (barren silts and clays, related metamorphic rocks)
      160 - Slicks (saline, alkali, soil structural, non-playa barrens)
      170 - Mass movement
      180 - Man-made barrens
      190 - Undifferentiated complexes of barren lands

  200 - WATER RESOURCES Subclasses

      210 - Ponds, lakes and reservoirs

         211 - Natural lakes and ponds
         212 - Man-made reservoirs and ponds

      220 - Water courses, permanent flowing

         221 - Natural (rivers and creeks)
         222 - Man-made (canals, ditches and aqueducts)

      230 - Springs, seeps, and wells
      240 - Bays, coves, and estuaries
      250 - Lagoons and bayous
      260 - Oceans, seas and gulfs
      270 -
      280 - Snow and ice

         281 - Ephemeral
         282 - Permanent (snow fields and glaciers)

      290 - Undifferentiated complexes of water resources

Subclasses (continued)

300 - NATURAL VEGETATION Subclasses

(For quick viewing of natural vegetation areas on CIR imagery)
301 - Vegetation density, vigor and growth high
302 -   "   "   "   "   "   moderate
303 -   "   "   "   "   "   low
304 - Vegetation present but dormant

(For identification of mapped delineations or ground locations)
310 - Herbaceous types (w/ or w/o platyphyllous succulents or <u>low</u> shrubs)

     311 - Lichen, cryptogam & related communities
     312 - Prominently annuals (grass-forb-succulents; usually grass aspect)
     313 - Forb types (broad-leaved forb aspect)
     314 - Bunchgrass steppe (tussock grass)
     315 - Sodgrass and mixed sodgrass-bunchgrass steppe and prairie
     316 - Meadows (Graminaceous/Cyperaceous)
     317 - Graminaceous Marshes (Panicums, Settaria, etc.)
     318 - Tule Marshes (Cyperaceae, Juncaginaceae, Typhaceae, etc.)
     319 - Undifferentiated complexes of herbaceous types

320 - Shrub-scrub types

     321 - Microphyllous, non-thorny scrub, generally with succulents
     322 - Microphyllous thorn scrub
     323 - Succulent and cactus scrub
     324 - Microphyllous saline tolerant and related scrub types
     325 - Shrub steppe (single species or simple mixtures of shrubs

     326 - Deciduous macrophyllous shrub
     327 - Evergreen macro/microphyllous shrub
     328 - (open number)
     329 - Undifferentiated complexes of shrub-scrub types

330 - Savanna types

     331 -
     332 -
     333 -
     334 -
     335 -
     336 -   (currently under revision)
     337 -
     338 -
     339 -

340 - Forest and Woodland types

     341 -
     342 -
     343 -
     344 -
     345 -   (currently under revision)
     346 -
     347 -
     348 -
     349 -

324 - Microphyllous saltsage and related shrub types

    324.1 - Saltsage (Atriplex) dominant types
    324.2 - Hopsage (Grayia) dominant types
    324.3 - Greasewood (Sarcobatus) dominant types
    324.4 - Winterfat dominant types
    324.5 - Blackbrush (Coliogyne) dominant types
    324.6 -

325 - Shrub steppe

    325.1 - Low sagebrush types
    325.2 - Tall sagebrush types
    325.3 - Silver sagebrush types
    325.4 - Rabbitbrush types
    325.5 -
    325.6 -
    325.7 - Mixed Shrub Steppe (Artemisia, Purshia, Symphoricarpos,
                            Amelanchier, Coleogyne)
    325.8 -
    325.9 - Undifferentiated complexes of shrub steppe

326 - Evergreen sclerophyll scrub

    326.1 - Live oak scrub or "chaparral"
    326.2 - Manzanita scrub or "chaparral"
    326.3 - Snowbrush scrub or "chaparral"
    326.4 - Curl-leaf mountain mahogany shrub
    326.5 - Chamise shrub types

327 - Deciduous, macrophyllous shrub

    327.1 - Oak shrub (Q. gambellii)
    327.2 - Maple shrub
    327.3 - Snowbrush, Hawthorn, Cherry, Rose shrub
    327.4 - Physocarpus/Oceanspray shrub
    327.5 - Willow/Alder/Birch shrub
    327.6 -
    327.7 -

341 - Needleleaf forest and woodland types

    341.01 -
    341.50 -
    341-70 -

    341.01 -
    341.02 -
    341.03 -   (currently under revision)
    341.04 -
    341.05 -
    341.06 -
    341.07 -
    341.08 -
    341.09 -
    341.10 -
    341.11 -
    341.12 -

For our particular study areas in Colorado/Arizona and California/Nevada, the quaternary level legend seems to be working very well. To show how the legend system phases into floristic criteria at this level, Table 2 summarizes the classes currently included within 324, Microphyllous salt tolerant and related shrub types the 325, Shrub Steppe types the 326, Evergreen macro-/microphyll scrub type, and 327, Deciduous, macrophyllous shrub types.

WORK SCHEDULE

Delays in receiving color products from NDPF user services have caused us to fall slightly behind schedule. We ordered color materials from Sioux Falls facility on November 10, 1972 during a visit by the PI to the USDI offices. No materials have been received at this date from that order.

We will be able to make rapid progress as soon as color products are received. We are progressing on color evaluation using an optical color combiner which is suitable for some general judgements but not suitable for the comprehensive evaluations we wish to make on high quality color composites.

There will be no significant change in projected completion of the investigation because of the delay in receipt of color products.

PROBLEMS

The problem of unsatisfactory print quality for some material received from user services mentioned in our Type I progress report number 2 has been brought to the attention of our technical monitor, Mr. Edward Crump. Samples of such prints are being sent to Dr. William Nordberg for his evaluation.

Reprints of materials ordered have been received and are unsatisfactory for the same reason the initial order was rejected.

We trust these problems will be corrected prior to the 1973 data shipments.

FUNDING

No change - costs are being controlled within the alloted budget.

PERSONNEL

No change.

PLANS FOR NEXT REPORTING PERIOD

Data received to date will be evaluated for use with the mapping legend. Modifications to legend will be made as defined in the first section of this report. Color combinations will be evaluated when received from NASA, and by use of an additive color device at EarthSat (we have determined that our order form to GSFC User Services for color composites of selected ERTS frames placed October 30, 1972 has been lost in transit and has now been reordered).

Final arrangements for cooperation from experiment station personnel and rice growers will be made in the near future.

A flight to the rice growing area of Louisiana is scheduled tentatively for the second week of March. Preparations for this trip will be made during the next reporting period. Excellent cooperation has been promised for the 1973 rice growing season.

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